DOCUMENT RESUME

ED 422 166 SE 061 680

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TITLE	International Mobility of Scientists and Engineers to the United States--Brain Drain or Brain Circulation?
INSTITUTION	National Science Foundation, Arlington, VA. Div. of Science Resources Studies.
REPORT NO	NSF-98-316
PUB DATE	1998-06-22
NOTE	6p.
AVAILABLE FROM	National Science Foundation, Division of Science Resources Studies, 4201 Wilson Blvd., Arlington, VA 22230; World Wide Web: http://www.nsf.gov/sbe/srs/stats.htm
PUB TYPE	Collected Works - Serials (022) -- Reports - Research (143)
JOURNAL CIT	SRS Issue Brief; Jun 22 1998
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Doctoral Degrees; Employment Patterns; *Engineers; *Foreign Workers; Higher Education; Labor Economics; Mobility; Occupational Mobility; Science and Society; *Scientists; *Underemployment
IDENTIFIERS	National Science Foundation

ABSTRACT

This Issue Brief reports on the international mobility of scientists and engineers to the United States and discusses student flows into the higher education system, the stay rates of foreign doctoral recipients, and their short and long term employment in United States industry, universities, and government. Information presented in the tables and graphs includes: (1) United States and foreign-born scientists and engineers in research and development in the United States in 1993 by sector and location of science and engineering degree; (2) stay rate of foreign students earning science and engineering doctorates at United States universities by selected regions from 1988-96; and (3) percentage of 1990-91 foreign science and engineering doctoral recipients from United States universities who were working in the United States in 1995 by country of origin. (DDR)

International Mobility of Scientists and Engineers to the United States--Brain Drain or Brain Circulation?

by
Jean M. Johnson
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NATIONAL SCIENCE FOUNDATION
Directorate for Social, Behavioral, and Economic Sciences

INTERNATIONAL MOBILITY OF SCIENTISTS AND ENGINEERS TO THE UNITED STATES—BRAIN DRAIN OR BRAIN CIRCULATION?

by Jean M. Johnson and Mark C. Regets

Division of Science Resources Studies
ISSUE BRIEF
NSF 98-316, June 22, 1998

U.S. universities are the conduit for acquiring, supporting, and retaining foreign S&E talent.

Foreign-born scientists and engineers (S&Es) contribute significantly to the brain power of the United States.[1] Considering the U.S. labor force with doctoral degrees in S&E fields, immigrants are 29 percent of those conducting R&D (table 1). Several decades ago, the emigration of such highly skilled personnel to the United States was considered one-way mobility, a permanent brain drain depriving the countries of origin of the "best and the brightest." More recently, however, the mobility of highly talented workers is referred to as "brain circulation," since a cycle of study and work abroad may be followed by a return to the home country to take advantage of high-level opportunities.[2] What do the data tell us about foreign-born S&E personnel in the United States? Are we seeing brain drain or brain circulation? This issue brief discusses student flows into U.S. higher education, the stay rates of foreign doctoral recipients, and their short- and long-term employment in U.S. industry, universities, and Government.

Table 1. U.S. and foreign-born scientists and engineers in R&D in the United States, by sector and location of S&E degree (1993)

Scientists and Engineers in U.S. R&D	Total		Education		Industry		Government	
	All degree levels	Ph.D.s	All degree levels	Ph.D.s	All degree levels	Ph.D.s	All degree levels	Ph.D.s
Total engaged in U.S. R&D	4,768,000	345,000	643,000	179,000	2,726,000	135,000	1,192,000	31,000
U.S.-born	4,160,000	244,000	500,000	128,000	2,367,000	90,000	1,108,000	26,000
Foreign-born	**608,000**	**101,000**	**143,000**	**51,000**	**359,000**	**45,000**	**84,000**	**5,000**
Location of S&E degree								
Foreign school	208,000	32,000	49,000	16,000	128,000	14,000	23,000	2,000
U.S. school 1/	400,000	70,000	94,000	35,000	231,000	31,000	60,000	4,000
Foreign-born in R&D as percent of total engaged in R&D	12.8	29.3	22.2	28.5	13.2	33.2	7.0	17.3
U.S. school as percent of foreign-born in R&D	65.8	69.7	65.7	67.9	64.3	69.6	71.4	69.2

1/ U.S. school was the location of the highest earned S&E degree.

NOTE: Data are headcounts of those with science or engineering degrees who reported R&D as their primary or secondary activity in the three surveys contained within the SESTAT database. These data differ from estimates of full time equivalent (FTE) scientists and engineers in R&D, and from estimates of scientists and engineers defined by occupation. Industry in this table includes the nonprofit sector. Numbers in general may differ from similar SRS tabulations due to the inclusion of degrees from foreign schools.

SOURCE: National Science Foundation, Division of Science Resources Studies, SESTAT database.

U.S. higher education and foreign S&E graduate students

The large foreign component of U.S. human intellectual capital is linked to the ability of U.S. higher education to attract, support, and retain foreign S&E graduate students. Foreign students, particularly those from Asia, represent a large fraction of enrollment and degrees in S&E fields in U.S. graduate institutions. In 1995, of the 420,000 graduate students in S&E programs, roughly 100,000 were foreign students, mainly from a dozen countries of origin. In 1996, at the doctoral level, foreign students (including those with permanent and temporary visas) earned 39 percent of the natural science degrees, 50 percent of the mathematics and computer

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[1] The data include individuals *educated* in science and engineering (S&E), and are not restricted to those with formal S&E *occupations*.

[2] Xiaonan Cao, "Debating 'Brain Drain' in the Context of Globalisation," *Compare*, Vol. 26, No. 3, British Comparative and International Education Society, 1996, pp. 269-284.

sciences degrees, and 58 percent of the engineering degrees. Students from China, India, South Korea, and Taiwan accounted for over half of these S&E doctorates.[3]

Financial support available from academic research activities appears to be a major factor associated with attracting foreign students to U.S. doctoral programs. More than 75 percent of the 10,000 foreign doctoral recipients at U.S. universities in 1996 reported their universities as the primary source of support for their graduate training.[4] Of those who did so, the majority reported that their primary support came in the form of research assistantships. Financial resources for research assistantships are provided to universities by Federal Government agencies, industry, and other non-Federal sources in the form of research grants. At the same time that academic research expenditures have been growing, the number of foreign doctoral students supported by university S&E departments has also been increasing. From 1985-96, academic research expenditures increased from $13 to $21 billion in constant (1992) dollars.[5] During the same period, the number of foreign doctoral students primarily supported as research assistants more than tripled—from 2,000 in 1985 to 7,600 in 1996.[6]

About 22 percent of foreign S&E doctoral recipients remain in the United States for postdoctoral study; 17 percent accept employment offers.

Between 1988 and 1996, foreign students from major Asian and European countries, Canada, and Mexico earned over 55,000 U.S. S&E doctoral degrees (table 2). During this period, about 63 percent of these doctoral recipients planned to remain in the United States after completion of their studies, and about 39 percent had firm plans to do so. The proportion of foreign students who remain in the United States, referred to as the "stay rate," differs widely by country. In the last decade, approximately half of the foreign doctoral recipients from China and India have sought and received firm opportunities for further study and employment in the United States. In contrast, only 23 percent of the doctoral recipients from South Korea and 28 percent from Taiwan accepted firm offers to remain in the United States (figure 1).

Table 2. Stay rate of foreign students earning S&E doctorates in U.S. universities, by selected regions: 1988-96

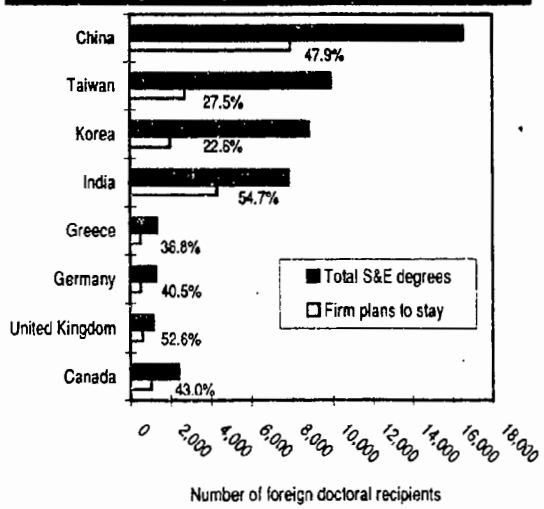
Regions	Total S&E Ph.D. degrees to foreign students	Number with plans to stay in U.S.	Percent	Number with firm plans to stay in U.S.	Percent
Total 1/	**55,444**	**34,917**	**63.0**	**21,779**	**39.3**
Asia	43,171	28,280	65.5	16,964	39.3
Europe	8,760	4,898	55.9	3,521	40.2
North America	3,513	1,739	49.5	1,294	36.8

1/ Foreign doctoral recipients from selected countries of Asia, Europe and North America. Asia includes China, India, Japan, South Korea and Taiwan. Europe includes all Scandanavian, Western and Eastern European countries. North America includes Canada and Mexico. Foreign students from these countries represent 74 percent of all U.S. foreign doctoral recipients in fields of science and engineering.

NOTE: Temporary and permanent visas.

SOURCE: National Science Foundation, Division of Science Resources Studies, Survey of Earned Doctorates, special tabulations.

Figure 1. Foreign S&E doctoral recipients and firm plans to stay in U.S., by country of origin: 1988-96



SOURCE: National Science Foundation, Division of Science Resources Studies, Survey of Earned Doctorates, special tabulations.

[3] National Science Board, "Higher Education in Science and Engineering," *Science and Engineering Indicators-1998* (Washington, D.C., 1998).

[4] National Science Foundation, Division of Science Resources Studies, Survey of Earned Doctorates, special tabulations.

[5] National Science Foundation, Division of Science Resources Studies, *National Patterns of R&D Resources: 1997.*

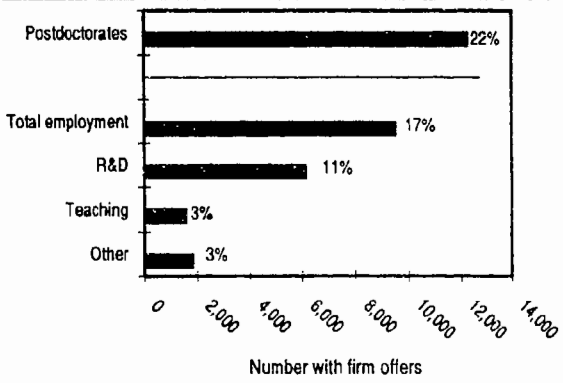
[6] National Science Foundation, Division of Science Resources Studies, *Statistical Profiles of Foreign Doctoral Recipients in Science and Engineering: Plans to Locate in the United States,* forthcoming, 1998.

The large majority of the 1990-91 foreign doctoral recipients from India and China were still working in the United States in 1995, compared to only 11 percent of South Koreans.

What do foreign S&E doctoral recipients who stay in the United States do?

Foreign S&E doctoral recipients remaining in the United States do so mainly by entering postdoctoral study. Of the 55,000 foreign students from these major countries of origin who earned S&E doctoral degrees between 1988 and 1996, about 22 percent (12,000) stayed on for postdoctoral study, and 17 percent (9,000) accepted employment in the United States (figure 2). Firm employment offers to foreign doctoral recipients are strongly geared toward research and development, mainly within business or industry.

Figure 2. Number and percent of all foreign S&E doctoral recipients with firm offers to remain in U.S., by primary work activity: 1988-96



SOURCE: National Science Foundation, Division of Science Resources Studies, Survey of Earned Doctorates, special tabulations.

The decision to remain for a postdoctoral appointment is, not surprisingly, greatest in fields where postdoctorates are a common career path. Over 50 percent of all foreign students earning doctoral degrees in the biological sciences remained in the United States for postdoctoral experiences; only 5 percent were offered jobs at universities or in industry. In contrast, in computer sciences, only 7 percent remained for postdoctoral experiences, while over 38 percent accepted employment.

Do foreign S&E doctoral recipients who plan to stay actually join the U.S. labor force?

A recent study of foreign doctoral recipients working and earning wages in the United States (Finn, 1997) shows that about 47 percent of the foreign students on temporary student visas who earned doctorates in 1990 and 1991 were working in the United States in 1995. The majority of the 1990-91 foreign doctoral recipients from India (79 percent) and China (88 percent) were still working in the United States in 1995. In contrast, only 11 percent of South Koreans who completed S&E doctorates from U.S. universities in 1990-91 were working in the United States in 1995 (table 3).

Table 3. Percentage of 1990-91 foreign S&E doctoral recipients from U.S. universities who were working in the United States in 1995, by country of origin

Country	Foreign S&E doctorates	Percent working in the United States
Total	**13,878**	**47**
China 1/	2,779	88
India	1,235	79
Japan	227	13
South Korea	1,912	11
Taiwan	1,824	42
England	142	59
Germany	177	35
Greece	240	41
Canada	417	46
Mexico	194	30

1/ The high stay rate of Chinese students is attributable to a one-time granting of permanent residence status in the United States (Chinese Students Protection Act) following China's response to student demonstrations.

NOTE: Includes foreign doctoral recipients with temporary visa status at the time of receipt of degrees in 1990-1991(not permanent residents).

SOURCE: Finn, Michael G., Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 1995 (Oak Ridge, TN: Oak Ridge Institute for Science and Education, 1997)

Do foreign S&E doctorates stay in the United States in the long term?

The same study looked at foreign doctoral recipients from 1970-72. Finn estimated that 47 percent were working in the United States in 1995, and that the stay rate for that group was around 50 percent during the 25 years leading up to 1995. There is no evidence of significant net return migration of these scientists and engineers after 10 or 20 years of work experience in the United States. The fairly constant stay rates indicate that any tendency of the 1970-72 cohorts to leave the United States after gaining work experience here has

been largely offset by others from the same cohort returning to the United States after going abroad. Remaining in the United States does not represent a complete brain drain on their home country. Choi has shown extensive networking by Asian-born faculty and researchers working in the United States to advise, disseminate information, and assist in building their home-country S&T infrastructure.[7] This is particularly true for the foreign-born faculty in S&E departments. In 1993, foreign-born faculty in U.S. higher education represented 37 percent of the engineering professors and over a quarter of the mathtics and computer science teachers.[8]

Conclusions

Data on mobility and stay rates of foreign-born S&Es working in the United States support the notion of brain circulation for some countries (Taiwan and South Korea) and somewhat more brain drain for other countries (China and India). In the aggregate, roughly half of all foreign doctoral recipients leave the United States immediately after completing their graduate eduation, and others leave after some years of teaching or industrial experience in the United States. In addition, some of those who remain in the United States network with home-country scientists. More research is needed, however, on the activities of foreign doctoral recipients who return to their home countries. For example, we need to know more about their contributions to their home countries' S&T infrastructure, including research, teaching, and science administration. Also, we need to be able to identify patterns of circulation and lengths of stay that are beneficial to the United States, the countries of origin, and the diffusion of S&E knowledge in the world.

[7] Choi, H. *An International Scientific Community-Asian Scholars in the United States.* (New York: Praeger, 1995).

[8] National Science Foundation, Division of Science Resources Studies, SESTAT database.

Information presented in this issue brief on foreign doctoral recipients and their planned stay rates comes mainly from the forthcoming NSF report: *Statistical Profiles of Foreign Doctoral recipients in Science and Engineering: Plans to Locate in the United States.* Data for this report were collected in the Survey of Earned Doctorates (SED) conducted by the National Opinion Research Center (NORC) for NSF and four other Federal agencies. Information on foreign-born scientists and engineers in the U.S. labor force is from the NSF Division of Science Resources Studies (SRS), SESTAT data system, available on the SRS World Wide Web site (http://www.nsf.gov/sbe/srs/).

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